The Bidding Process

At the beginning of each period, round 0 will open for you to submit sealed bids, in francs, for the single items A, B and C. You can submit a bid on any or none of these items. Once every participant has submitted a bid the computer will select the highest bid submitted for each item. The highest bid for each item will be designated as the provisional winner for that item. This information along with second highest bid for each item will be displayed to each participant. Round 2 will then begin for the period and new bids can be submitted. However, in order to be able to bid in a round, you must be an **active participant** in the previous round. An active participant is a participant who is either the highest bidder for an item from one of the last two rounds or submitted an **competitive bid** in the previous round. A bid for an item is competitive if it is at least 5% higher than the provisional winning bid for the item. Once you are an inactive participant in a period you can not submit any further bids in that period.

Bidding in a period will **continue** if either of the two following conditions occur:

i. The highest bid for any of the items is 5% higher than the previous round provisional winning bid for the item; or

ii. If for any item two participants have tied for highest bid in the current round.

If i and ii do not occur, the bidding process stops and the items are awarded to those individuals (**assigned participants**) who have the current highest bid for the item. An assigned participant can withdraw and not pay his bids. However, if that occurs all the bids of that participant are withdrawn and the next highest bidder for that item becomes an assigned participant, with the right to accept or refuse the item at their bid price. If the second highest bidder refuses we will give the right to the next highest bidder of the item.

Summary of the bidding process

1. At the beginning of each round in a period each active participant can send in separate bids for each item.
2. An active participant is a participant who is either the highest bidder for an item from the last two rounds or submitted a competitive bid in the previous round.
3. A bid for an item is competitive if it is at least 5% higher than the provisional winning bid for the item
4. Once you are an inactive bidder you can not submit any further bids in the period.
5. The process stops if either the highest bid for each item is less than 5% higher than the previous round highest bid and for that item there is no tie for the highest bid.
6. When the process stops, the items are awarded to those individuals (assigned participants) who have the current highest bid for the item.
7. An assigned participant can withdraw his bid. However, if that occurs all the bids of that participant are withdrawn and the next highest bidder for that item becomes an assigned participant.

Accounting for your Profits

When the period ends, if you are an assigned bidder who has not withdrawn your bids, you fill out your period account line by listing the Redemption Value for the package you were assigned and subtracting the sum of your winning bids. For example, suppose Participant 2 was assigned, in period 1, items A and C with winning bids of 20 and 30 respectively. The value for the package is the maximum of the values for the single item packages (60 for our example).

ACCOUNTING SHEET

Period	Items Assigned	Value of Package		Sum of Your Winning Bids	Profit
1	A, C	60	-	50	= 10
			-		=
			-		=

APPENDIX C.

INSTRUCTIONS

AUSM (5X6)

You are about to participate in an experiment in which you will make decisions in a market. Your decisions will result in earnings in U.S. currency which will be yours to keep. In this experiment all transactions will be stated in *francs*. You can convert your franc earnings into U.S. dollars at a rate of ____ francs to 1 dollar at the end of the experiment.

The experiment will be broken-up into a series of **periods**. Each period in turn will be divided into a series of **rounds** in which you will make decisions. At the beginning of each period you will be given a **Redemption Value Sheet** which describes the value to you of decisions you might make. *You are not to reveal this information to anyone.*

How to Read a Redemption Value Sheet

A Redemption Value Sheet is a list of **packages of items** (there are 6 items labeled as A, B, C, D, E and F) and the value of each to you in francs. Below is an abbreviated sample Redemption Value Sheet with four packages (the packages are identified as a, b, c and abc) which contain a specific configuration of items.

Items

Package Name	A	B	C	**Value in Francs**
a	Y	N	N	60
b	N	Y	N	49
c	N	N	Y	29
abc	Y	Y	Y	202

For example, in the above sheet, package abc consisting of the items A, B and C has a value of 202 francs. However, if you were only to obtain item A you would receive 60 francs. Your earnings for a period are the value of the packages you implement at the end of the period, for which you have obtained the items in that package, minus your cost of obtaining the packages.

How the Redemption Values are Determined

You will be one of 5 participants in this market. At the beginning of a period each participant will be given a set of packages and associated redemption values for the packages. The set of packages and values, from which yours will be selected, are determined as follows:

1. Each of the single-item packages (a,b,c,d, e,f) will have their values taken independently from the interval [0,10]. Each value in this interval will be equally likely to be selected.
Example:
Package a gets the value 4 Package b get the value 7.

2. The experimenter will select 7 of the 15 two-item packages (ab, ac, ad,.... ,ef) which have their values taken independently from the interval [20,30]. Each value in this interval will be equally likely to be selected.
Example:
Package ce get the value 27, Package de gets the value 21.

3. 11 of the 20 three-item packages will be selected and their values will be drawn independently from the interval [110,130] all of which are equally likely.
Example:
Package abc get the value 111, Package cde gets the value 125.

4. The package abcdef will have its value drawn from the interval [140,180] all of which are equally likely.

Summary to this Point

- There will be a total of 25 packages (6 single-item packages, 7 two-item packages, 11 three-item packages and 1 six-item package) generated each period to be distributed among the six participants each period.

- Each participant will be assigned 5 of the packages Thus, no one has duplicate packages.

- The values for the packages were determine as follows:
  - Single-item package values are selected from the interval [0,10]
  - Two-item package values are selected from the interval [20,30]
  - Three-item package values are selected from the interval [110,130]
  - Six-item package value is selected from the interval [140,180]

- The sequence of events are as follows:

Period 1 begin Obtain Redemp. Val.	Bidding Rounds for Period 1	Bidding Ends Record Profits	Period 2 begin Obtain Redemp. Val.

The Bidding Process

At the beginning of each period, round 0 will open for you to submit bids to the market, in francs, for packages containing the items A, B, C, D, E and F. You can submit bids on any combination of the items. For example, you could submit a bid for the package with items A and C for a price of 20, as depicted below:

A Sample Bid

A	B	C	$
X		X	20

The bid will be provisionally accepted if its price is greater than the sum of the bids it must displace. For example , suppose the set of provisional bids were as depicted below: Participant 1 has bid for item A for a price of 20 and participant 2 has bid for the package BC for a price of 30. If you wanted a package with items A and C to be provisionally accepted you would have to bid a price over 50 in order to ***bump*** participants 1 and 2.

Provisionally Accepted Bids in Round 1

Participant	A	B	C	$
1	*X*			*20*
2		*X*	*X*	*30*

The provisionally assigned packages and bids will be posted for all participants to see. In addition to submitting bids directly to the market, you can submit binding bids to a ***standby queue***. Only the highest bids for packages submitted to the standby queue will be listed. The standby queue is provided to allow participants to signal there willingness to "combine" bids to get assigned. Only the best bids are displayed. For example, suppose that participant 2 has a bid on the standby queue for item B at a price of 10 as depicted below. If you wanted the package AC to be provisionally accepted, you would only have to submit a price greater than 40 to the market. Once the combined orders are sent to the market, they bump the previous accepted bids but are listed separately.

Standby Queue

Participant	A	B	C	$
2		X		10

Example:

Participant 3 "combines" his bid for AC with price 41 together with participant 2's bid in the standby queue.

RESULT OF THE BUMP

New Provisionally Accepted Bids in Round 1

Participant	A	B	C	$
3	***X***		***X***	***41***
2		***X***		***10***

After the market has been open for a few minutes in a round we will pause the period. <u>During the pause no new bids can be sent to the market.</u> At the beginning of the pause you can delete your bids in the standby queue. New binding bids can then be submitted to the standby queue during the pause. After a short period of time the next round in the period will open.

The period will end if the following condition occurs

No new bids enter the market that are 10% over the bids they bump within 3 minutes.

If condition does not occur, the bidding process will continue for the period. When the process stops the items are awarded to those individuals (**assigned participants**) who are part of the current provisionally assigned participants.

Summary of the bidding process

1. At the beginning of each round in a period each participant can send in bid packages to the market or standby queue.
2. A bid sent to the market will be accepted if its price is higher than the sum of prices of the package that it must displace.
3. You can "combine" your bid with any of those on the standby queue and send them to the market.
4. In a round of a period, the market will be open for several minutes. It will then close temporarily and only standby bids can be submitted.
5. Next the period will be reopened for bidding in the market and standby queue.
6. The period will stop if there are no new bids within 3 minutes.

Accounting for your Profits

When the period ends you fill out your period account line by listing the Redemption Value for the package you where assigned and subtract its bid. For example, suppose Participant 2 was assigned, in period 1, items A and C with winning bids of 20 and 30 respectively. The value for the package is the maximum of the values for the single item packages (60 for our example).

ACCOUNTING SHEET

Period	Items Assigned	Value of Package		Your Winning Bids	Profit
1	A, C	60	-	50	= 10
			-		=
			-		=

.
.
.

INSTRUCTIONS

Simul.-Indep. (5X6)

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For example, in the above sheet, package abc consisting of the items A, B and C has a value of 202 francs. However, if you were only to obtain item A you would receive 60 francs. Your earnings for a period are the value of the packages you implement at the end of the period, for which you have obtained the items in that package, minus your cost of obtaining the packages.

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1. Each of the single-item packages (a,b,c,d, e,f) will have their values taken independently from the interval [0,10]. Each value in this interval will be equally likely to be selected.
Example:
Package a gets the value 4 Package b get the value 7

2. The experimenter will select 7 of the 15 two-item packages (ab, ac, ad,.... ,ef) which have their values taken independently from the interval [20,30]. Each value in this interval will be equally likely to be selected.
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3. 11 of the 20 three-item packages will be selected and their values will be drawn independently from the interval [110,130] all of which are equally likely.
Example:
Package abc get the value 111, Package cde gets the value 125.

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- The values for the packages were determine as follows:
  - Single-item package values are selected from the interval [0,10]
  - Two-item package values are selected from the interval [20,30]
  - Three-item package values are selected from the interval [110,130]
  - Six-item package value is selected from the interval [140,180]

- The sequence of events are as follows:

Period 1 begin Obtain Redemp. Val.	Bidding Rounds for Period 1	Bidding Ends Record Profits	Period 2 begin Obtain Redemp. Val.

The Bidding Process

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ii. If for any item two participants have tied for highest bid in the current round.

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Summary of the bidding process

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Accounting for your Profits

When the period ends, if you are an assigned bidder who has not withdrawn your bids, you fill out your period account line by listing the Redemption Value for the package you were assigned and subtracting the sum of your winning bids. For example, suppose Participant 2 was assigned, in period 1, items A and C with winning bids of 10 and 5 respectively. The value for the package is the value of the package ac (suppose it is 25). Then the accounting would be:

ACCOUNTING SHEET

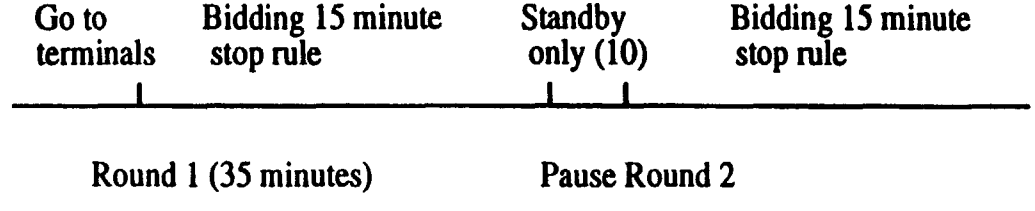
Period	Items Assigned	Value of Package		Sum of Your Winning Bids	Profit
1	A, C	25	-	15	= 10
			-		=
			-		=

[redacted]

APPENDIX D.

Demo Procedures

- We will auction off 54 items to ten participants (values described later)
- Ten subjects recruited who have participated in several experiments and understand the process and software
- Subjects will make the decisions (they keep the earnings)
- At most two observers per subject are allowed
- The auction will last at most 90 minutes (two rounds lasting 35 minutes)
- Observers can leave at any time
- The timeline is as follows:



Who Wants What How Much

- 10 subjects (index i), 54 MTAs (index j), many MTA packages (index k)

True value : $V_{ik} = C \cdot S_i \cdot P_k \cdot b(P_k)$

Told value : $\tilde{V}_{ik} = \tilde{C}_i \cdot S_i \cdot P_k \cdot b(P_k)$

Common value : $C \sim [20,30]$

Signal : $\tilde{C}_i = C + \sim [-5,5]$

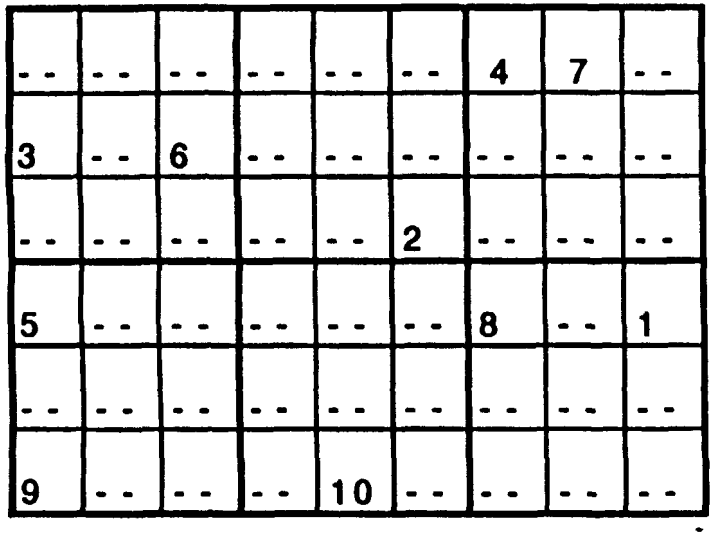
Strength : $S_i \sim [100,125]/100$

Population : $P_k = \Sigma_{j \in k} P_j$

Factor : $b(P) = 1/5 + 3/(1+1/P)$

	p	b(p)
min →	.01	.2
	.25	.8
	.5	1.2
mean →	1	1.7
	2	2.2
	4	2.6
	8	2.9
	16	3.0
	32	3.1

Demo Land



Homes

```
-- -- -- -- -- -- -- -- --
-- -- -- -- -- -- -- -- --
-- -- -- -- -- -- -- -- --
-- -- -- -- 43 53 -- -- --
-- -- -- 34 44 54 -- -- --
-- -- -- -- 45 55 -- -- --
```

Sample MTA Package

```
-- -- -- 30 40 50 -- -- --
-- -- -- 31 41 51 -- -- --
-- -- -- 32 42 52 -- -- --
-- -- -- 33 43 53 63 73 83
-- -- -- 34 44 54 64 74 84
-- -- -- 35 45 55 65 75 85
```

Sample Region Package

Attachment 2

PCS Auction Design Conference
Conference Attendees

Name	Affiliation
Michael Rothkopf	Rutgers University
Tony Labozzetta	Cantor Fitzgerald
Pamela Riley	PacTel Corporation
Mark Bykowsky	NTIA
Joe Gattuso	NTIA
Richard Dowling	General Communications Inc.
Greg Duncan	GTE Laboratories
David Salant	GTE Laboratories
Mike Patrick	Pacific Bell
Donna Branson	Southwestern Bell Corp.
Michael Williams	Analysis Group Inc.
Warren Lavey	Skadden Arps Slate Meagher & Flom
Steve Webert	PCS Associates
Jeremy Bulow	Stanford University
Jason Lee	Ameritech
Alan Ferber	Ameritech
Paul Milgrom	Stanford University
Peter Clark	Mercer Management Consulting
Jonathan Levy	FCC
David Moore	Congressional Budget Office
Evan Kwerel	FCC
Ian Hutton	I.A.M. Communications Corp.
Keith Walker	ISIS Communications
Harold Higgins	ISIS Communications
Jacqueline Nethersole	NYNEX
Paul Brewer	Caltech
Robin Hanson	Caltech
Takashi Ishikida	Caltech
Wes Boudville	Caltech
Lende Lancaster	BellSouth
Rick Kimsey	BellSouth
John Branning	GTE Telops
Larry Latham	Larry Latham Associates
Anne Phillips	APC
Ron Harstad	Rutgers University
Laura Phillips	Dow Lohnes & Albertson
Bob Weber	TDS/Kellog GSM
Terry Lanphear	GTE Telops
Tom Watson	GTE Telops
John McMillan	University of California (San Diego)
Carol Bjelland	GTE
Tom Palfrey	Caltech
Kurt Zobenica	Caltech
Jacques Cremer	IDEI
Dale Carlson	Pacific Stock Exchange

Electronic Bidding for PCS Spectrum

Is EICA the Answer?

Attachment 3

Thomas P. Watson

GTE Telephone Operations

January 20, 1994

PCS Spectrum Auction

NTIA Perspective

- PCS spectrum to be auctioned, with FCC required to begin assigning licenses by May 7,1994

- 2,562 licenses to be auctioned which:
  - * have different market values and,
  - * are value interdependent

- Electronic Interactive Combinatorial Auction (EICA) system viewed by NTIA as practical.

PCS Spectrum Auction

GTE Perspective

- GTE concurs that an electronic auction system may be practical for the PCS spectrum auction,

- Interactive bid process should be employed. The bid process should provide for:
  - * highest bids for each service area should be continuously posted
  - * increased bids entertained until reasonable period of inactivity passes

- The proposed Milgrom methodology viewed by GTE as technically feasible.

PCS Spectrum Auction

Electronic Auction Feasibility Issues

Network Reliability, Integrity, Ubiquity, and Security

- Depending on the implementation, no custom software would be required, using off-the-shelf products, such as E-mail or fax servers;

- System and communications security is available using off-the-shelf products;

- Depending on the system implementation, service availability would be provided by the Public Switched Telephone Network (PSTN).

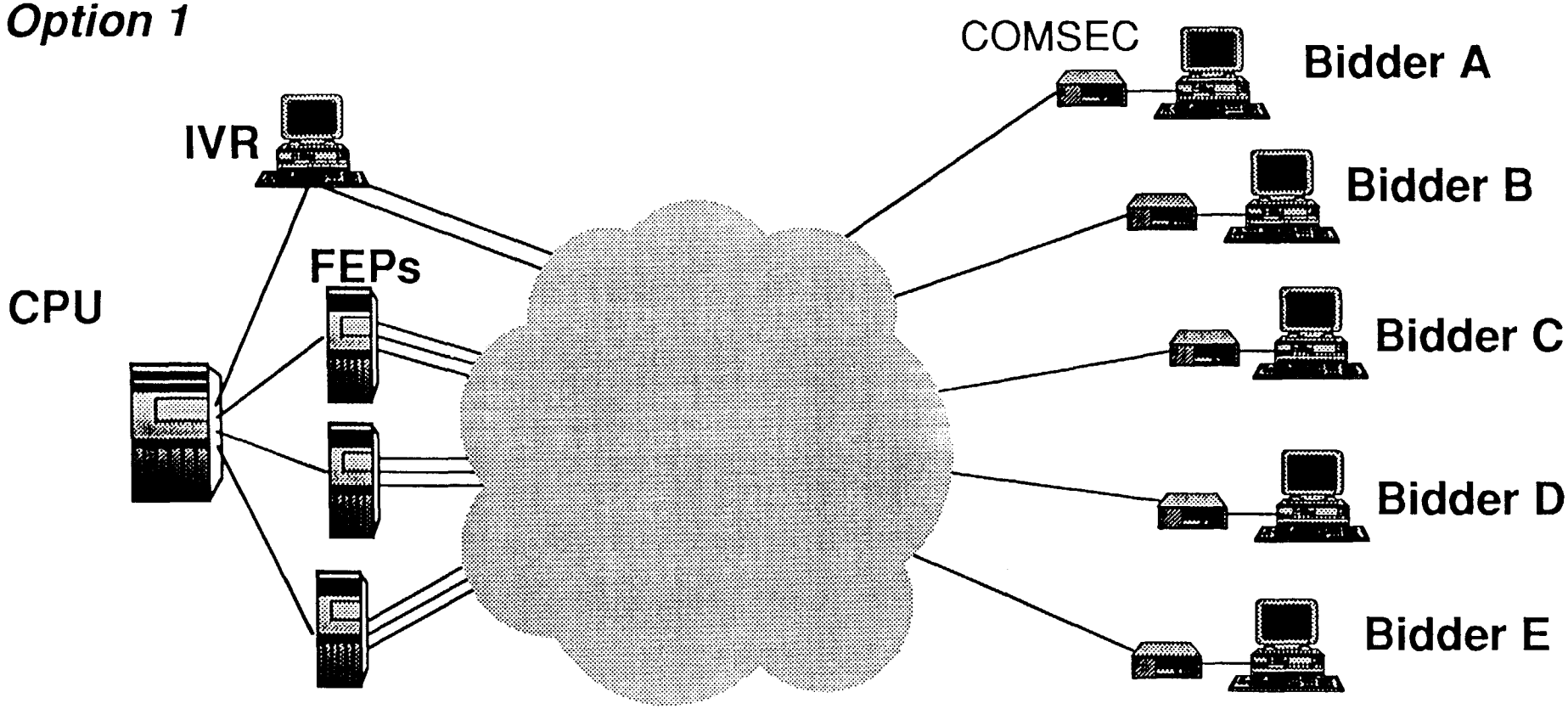
PCS Spectrum Auction

Electronic Auction Hypothetical Options

- **Implementation of an interactive electronic auctioning system is both practical and feasible,**
- **GTE bases conclusion on analysis of technical issues associated with conduct of an auction which meets "fairness" requirements,**
- **All auction system options include some element of risk,**
- **Auction system options include discussion of advantages and disadvantages associated with each.**

PCS Spectrum Auction

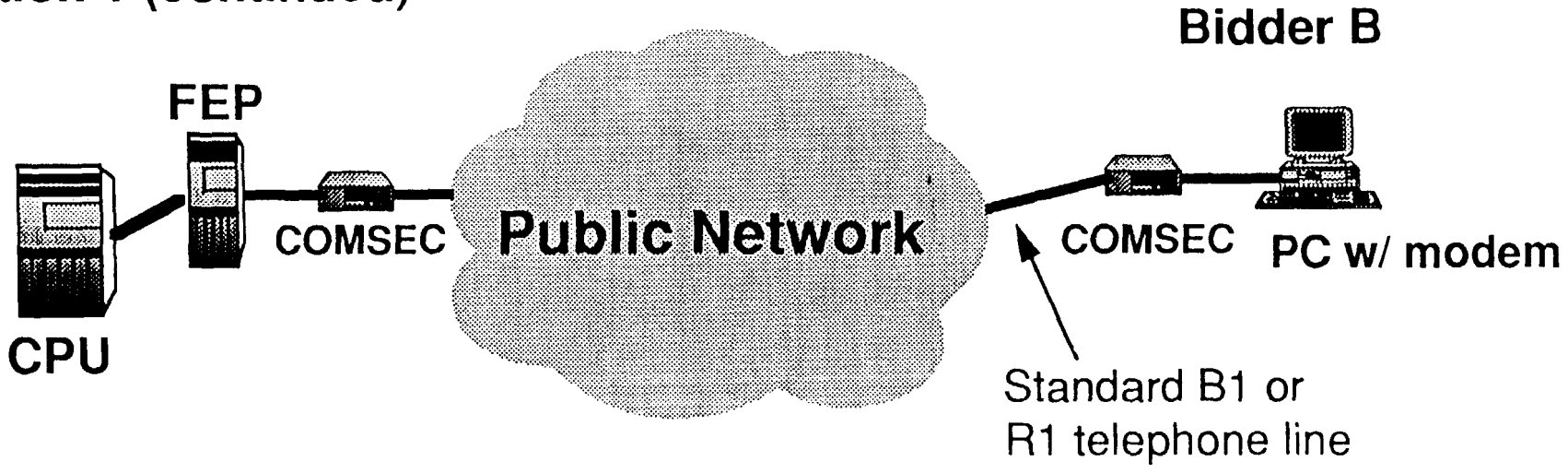
Option 1



1. Communications provided by standard telephone circuits.
2. COMSEC equipment located at both source and destination.
3. Front End Processors (FEPs) would provide call management.
3. Interactive Voice Response (IVR) system could provide *read only* access to auction database.
4. System scalable to account for varying numbers of bidders.

PCS Spectrum Auction

Option 1 (continued)



1. Bidder pre-qualified; as part of process, bidder receives auction package including COMSEC equipment and crypto from FCC or contractor;
2. Bidder fills out form with required entries;
3. When auction opened, bidder calls auction location to make bid (system and communications security ensure bid confidentiality);
4. Bids accessed and collated at central location.
5. If bids are posted daily, this would allow bidders to adjusts bids and resubmit.

PCS Spectrum Auction

Option 1 (continued)

Advantages:

- Ubiquitous: allows bidders to be located anywhere and thereby levels the playing field between big and small, urban and rural;
- Reliable: public network reliable due to built-in redundancies
- Secure: cryptographic security equipment and system security assure bid confidentiality until processed by request;
- Allows for simultaneous bidding methodology, such as that proposed by Milgrom through Pac Bell/Nevada Bell

Disadvantages:

- System sizing could be a risk with very large (tens of thousands) number of bidders.
- Low speed phone lines, although ubiquitous, could hinder transfer of large data files (if large file transfer required).